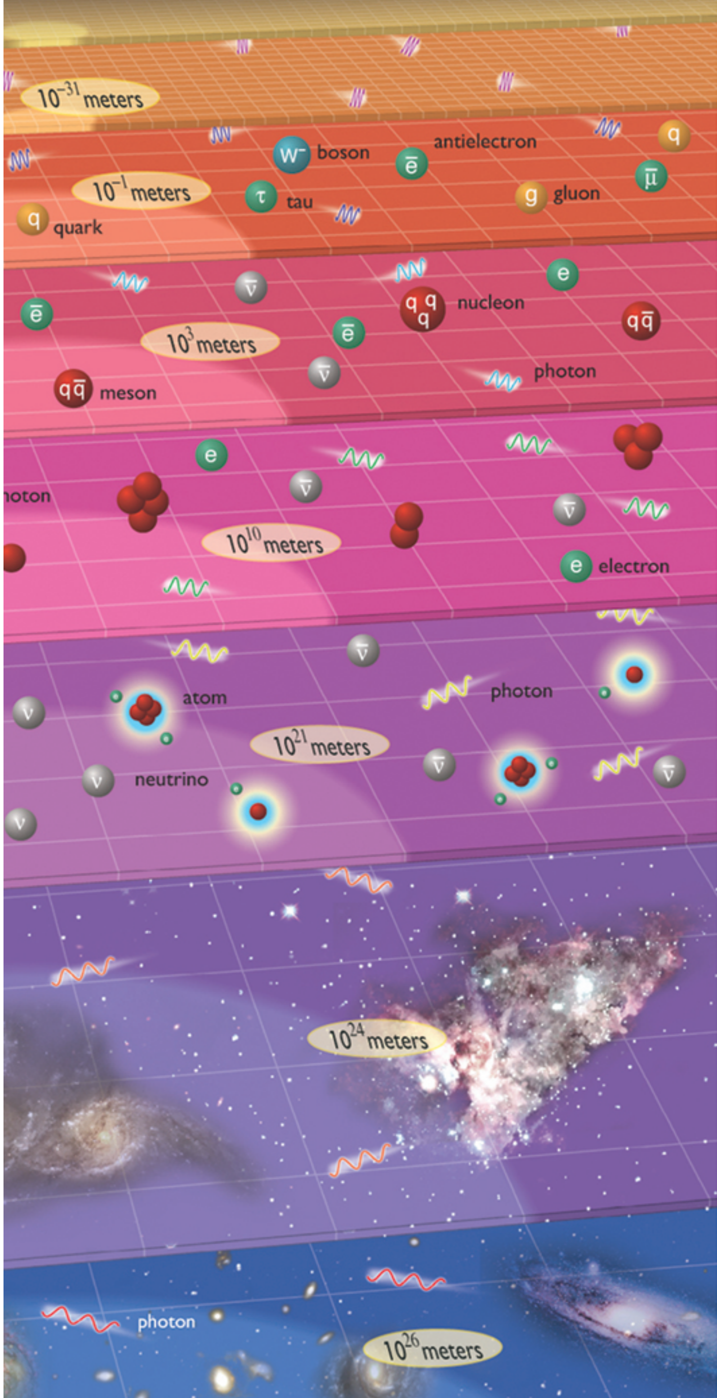
FATE OF THE UNIVERSE

n of the universe are illustrated below.

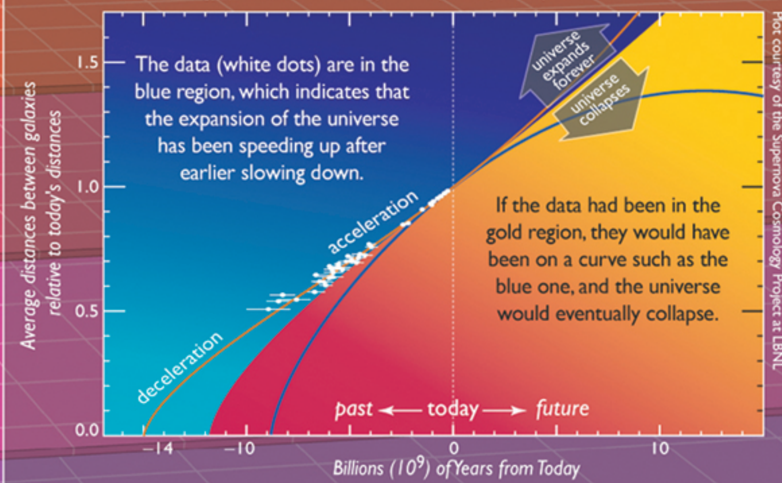
he universe. Here one region has been illuminated
pansion is far greater than can be shown here.



The Accelerating Universe

By observing another astronomical relic, distant exploding stars called supernovae, astrophysicists are digging ever further back into the history of the universe.

The plot shows data (white dots) from distant supernovae. The orange curve, with the best fit to the supernovae data, shows that billions (10^9) of years ago the expansion of the universe began to accelerate (the data curve upward slightly). This acceleration is attributed to a new form of energy called "dark energy" that pulls space apart.



Before the supernova research, physicists believed that the whole expansion history of our universe would lie in the gold region, where the expansion would be slowed by the attractive force of gravity. Now we see from the supernova data that the expansion history lies in the blue region, where attractive and repulsive forces compete for dominance.

The Fate of the Universe

Whether the expansion of the universe will speed up, slow down, or even possibly reverse into collapse depends (according to gravitation theory) on the amount and types of matter and energy in it.

The ordinary matter – atoms and nuclei – that formed in the early universe can account for the visible mass in galaxies and clusters. But the amount of ordinary matter falls far short of the total mass needed to bind a galaxy or cluster together gravitationally and explain its internal motions. So an extraordinary new type of matter, not made of atoms or nuclei, must exist; it is called dark matter because it is not directly visible.

Even stranger, recent observations of supernovae in distant galaxies show that the expansion of the universe is in fact accelerating. An exotic dark energy may be causing this acceleration through a cosmic repulsion that overwhelms the pull of gravity due to matter.

Composition of the Universe

The nature of dark energy and dark matter are two of the great questions facing cosmology and particle physics. Perhaps dark energy is the cosmological constant, introduced by Einstein in 1917. Perhaps both are new parts of particle physics, tied to the very earliest moments of the universe and having to do with the nature of physics and spacetime itself.

Not all answers in science are known yet! With research and experiments under way in astrophysics, particle physics, and nuclear physics, we may be the first generation to learn what most of the universe is made of and what is the fate of the universe.

nic Address

ilky Way galaxy, which is one of more
e visible universe.

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MS 50R-6008, Lawrence Berkeley National Laboratory, Berkeley, CA, 94720. For information on charts, websites, text materials, hands-on classroom activities and workshops, see: CPEPweb.org.

ational Science Foundation, Lawrence Berkeley National Laboratory. Photos courtesy of **NASA.**